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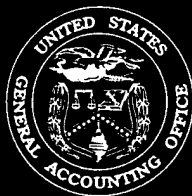
United States General Accounting Office

Report to Congressional Committees

March 2000

# F-22 AIRCRAFT

## Development Cost Goal Achievable If Major Problems Are Avoided



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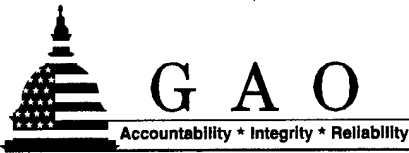
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## Abbreviations

DOD      Department of Defense





United States General Accounting Office  
Washington, D.C. 20548

National Security and  
International Affairs Division

B-280222

March 14, 2000

Congressional Committees

As required by the National Defense Authorization Act for Fiscal Year 1998,<sup>1</sup> we reviewed the Air Force's engineering and manufacturing development program for the F-22 aircraft. The F-22 is an air superiority<sup>2</sup> aircraft with advanced features to make it less detectable to adversaries (stealth characteristics) and capable of high speeds for long ranges. It has integrated aviation electronics (avionics) to greatly improve pilots' awareness of the situation surrounding them. The objectives of the F-22 development program are to (1) design, fabricate, test, and deliver 9 F-22 flight test aircraft and 25 flight-qualified engines; (2) design, fabricate, integrate, and test the avionics suite; and (3) design, develop, and test the support and training systems. The F-22 is being developed under contracts with Lockheed Martin Corporation (for the aircraft) and Pratt & Whitney Corporation (for the engine).

For this report, an update to a report we issued in 1999, we assessed the extent to which the F-22 development program is meeting its performance, schedule, and cost goals.<sup>3</sup> We also determined whether the Air Force is likely to complete the development program as planned without exceeding the cost limitation established by the act. The act also requires us to certify whether we had access to sufficient information to make informed judgments on matters covered in this report.

There is a congressional cost limitation for the F-22 development program. The limitation is currently \$18.880 billion, but Department of Defense (DOD) officials said the limitation is being revised and is expected to be \$20.4 billion, with the amount to officially be announced in May or June 2000. The revision is mostly to recognize program direction included in the fiscal year 2000 appropriation act, which added flight test aircraft to the

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<sup>1</sup> PL. 105-85 (Nov. 18, 1997).

<sup>2</sup> Air superiority is the degree of air dominance that allows the conduct of operations by land, sea, and air forces without prohibitive interference by the enemy.

<sup>3</sup> *F-22 Aircraft: Issues in Achieving Engineering and Manufacturing Development Goals* (GAO/NSIAD-99-55, Mar. 15, 1999).

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development program. The Air Force plans to complete the development program, which began in 1991, in August 2003. As of December 1999, the Air Force had accepted two flight test aircraft and had completed over 500 flight test hours—about 13 percent of the planned total.

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## Results in Brief

In 1999, the Air Force made progress in demonstrating the F-22's expected performance. The Air Force continues to estimate that by the end of the development program, the F-22 will meet or exceed its performance goals. At this time, we have no evidence indicating that the performance parameters will not be met. However, the Air Force's performance estimates are based on limited flight test data, computer models, ground tests, and analyses and will not be confirmed until flight tests are completed.

While the development program made progress in achieving its schedule goals in 1999, some tests and scheduled activities established in 1997 were delayed because of continuing problems such as delays in delivery of flight test aircraft and in completion of testing of nonflying ground test aircraft. Even though the Air Force encountered problems that caused delays in completing flight and other test activities, it has not extended the August 2003 completion date of the development program and therefore may not be able to complete development flight tests before the development program is scheduled to end. Further, the schedule for completion of avionics development appears optimistic. Avionics is being developed in segments (blocks), with completion of each segment dependent on completion of prior segments. Although it postponed the completion dates of the first two avionics software segments from the 1997 schedule, the Air Force moved up the completion dates of subsequent segments.

In late 1998, the Air Force identified \$667 million in potential cost increases that could cause the development program to exceed its cost limitation. By December 1999, the Air Force had identified an additional \$90 million because of higher than expected contractor costs, bringing the total potential cost increase to \$757 million. Despite these potential cost increases, the F-22 development program could still be managed within its cost limitation because the Air Force and contractors have identified \$860 million in potential cost offsets. Should further significant cost increases materialize, however, the development program may need to be scaled back, or other ways may need to be found to reduce the costs. Challenges remain in completing the development program within the congressional cost limitation and as scheduled. However, the Air Force has

identified sufficient cost offsets to more than cover all identified potential cost increases and is aggressively managing the program. As a result, we are making no recommendations.

In commenting on a draft of our report, the Department of Defense stated that it concurred.

## Background

Since the beginning of the F-22 development program in 1991, the Air Force's estimated cost to develop the aircraft has increased. Cost trends in 1995 showed a potential for costs to increase further. Concerned about these growing costs, the Assistant Secretary of the Air Force for Acquisition established the Joint Estimating Team to estimate the most probable costs to complete F-22 development and production. The team consisted of personnel from the Air Force, DOD, and private industry. The team concluded in 1997 that additional time would be required to complete the development program and estimated that costs would increase from \$17.4 billion to \$18.688 billion. The team recommended several changes to the development program's schedule, including slower manufacturing for a more efficient transition from development to low-rate initial production and an additional 12 months to complete avionics development. The Air Force and the Under Secretary of Defense for Acquisition, Technology, and Logistics generally adopted the team's recommendations to extend the development program schedule, including the dates for accomplishing interim events.<sup>4</sup>

The National Defense Authorization Act for Fiscal Year 1998 established a cost limitation of \$18.688 billion (an amount that mirrored the team's estimate) for the development program. The act instructed the Secretary of the Air Force to adjust the cost limitation for the amounts of increases or decreases in costs attributable to economic inflation after September 30, 1997, and for compliance with changes in federal, state, and local laws enacted after September 30, 1997. Since then, the Air Force has adjusted the program's cost limitation to \$18.880 billion. DOD officials said the limitation will be adjusted again to \$20.4 billion in May or June 2000 to recognize the program's fiscal year 2000 legislation, which added flight test aircraft to the development program.

<sup>4</sup> For more information on the team's recommendations, see *Tactical Aircraft: Restructuring of the Air Force F-22 Fighter Program* (GAO/NSIAD-97-156, June 4, 1997).

For fiscal year 2000, the Air Force requested \$1.6 billion for initial production of six F-22 aircraft. Both authorization and appropriations acts for fiscal year 2000 established further congressional direction for the program. The authorization act<sup>5</sup> required that before initial production begins, the Secretary of Defense must certify that the test plan is adequate for determining whether the F-22 is effective and suitable for its mission, and that the development program can be executed within the cost limitation. The appropriations act<sup>6</sup> did not approve initial production but approved funding for acquisition of additional flight test aircraft with research, development, testing, and evaluation funding. The act restricted award of a fully funded contract for initial production until (1) the first flight of an F-22 with block 3<sup>7</sup> avionics software is conducted; (2) the Secretary of Defense certifies to congressional defense committees that criteria identified in the act for award of initial production contracts have been met; and (3) the Director of Operational Test and Evaluation reports on the adequacy of testing to measure and predict the performance of avionics systems, stealth characteristics, and weapon delivery systems.

## Extent to Which F-22 Development Program Is Meeting Performance Goals

In December 1999, the Air Force estimated that by the time the development program ends, the F-22 will have met and in many instances exceeded the goals for major performance parameters. These include 10 parameters on which the Air Force reports regularly to the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics. At this time, we have no evidence indicating that the performance parameters will not be met. However, we observe that the Air Force's performance estimates are based on limited flight test data, computer models, ground tests, and analyses. Most ground and flight tests will have to be completed before the estimates are confirmed.

Table 5 in appendix I shows the goal for each parameter, the estimated performance for each parameter as of December 1999, and the Air Force's latest estimates of the performance expected to be achieved for each parameter by the end of the development program.

<sup>5</sup> P.L.106-65 (Oct. 5, 1999).

<sup>6</sup> P.L.106-79 (Oct. 25, 1999).

<sup>7</sup> Block 3 is the third major avionics software segment, which brings most avionics software into an integrated system.

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## Extent to Which the F-22 Development Program Is Meeting Schedule Goals

The F-22 development program made progress toward meeting its schedule goals in 1999. It carried out flight, engine, and avionics tests and met a crucial test requirement deadline. However, the Air Force did not achieve several goals established in 1997, when the program was last restructured. In particular, the development flight test program has been delayed and may not be able to complete the number of flight tests planned before the development program is scheduled to end in August 2003, the schedule for completion of avionics development appears optimistic, and tests of nonflying ground test aircraft are behind schedule. Further delays in completing these activities could delay the completion of the development program, thereby increasing development costs.

The Air Force has modified many of its detailed schedules, delaying and in a few instances, moving up the dates for which various events are scheduled to occur. The Air Force said the 1997 schedule is outdated and it no longer manages the program to achieve the schedules of events as restructured in 1997. They said many events were not achieved as planned and the schedules had to be revised to reflect different plans for completing development at the same time. Because the program was last restructured in 1997 and the congressional cost limitation mirrored the program as restructured, we used the cost and schedule plans established in 1997 from the team's study as an analytical baseline in our assessment of cost and schedule goals for the F-22 development program.

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## Progress Made in 1999

Through 1999, the Air Force completed over 500 flight test hours (about 200 of which were completed in 1998), conducted avionics and engine test activities, and began testing the nonflying ground test aircraft. By December 1999, the Air Force had met test requirements set by the Under Secretary of Defense for Acquisition, Technology, and Logistics as a prerequisite for acquiring production representative test aircraft approved by Congress for fiscal year 2000. The test requirements are included in appendix II.

Some of the more notable tests conducted on the F-22 in 1999 included

- supercruise (sustained flight at 1½ times speed of sound without using engine devices that consume significant amounts of fuel);
- flight with open weapon bays;
- ability to operate at many different altitudes and speeds in flight zones E-2, E-2A, E-3, E-3A, and E-4;



- flight with thrust vectoring<sup>8</sup> in unconventional situations;
- structural (static) tests up to 100 percent of the design limit load on critical structure (full requirement is to test the aircraft's structure to 150 percent);
- demonstration of the second major F-22 avionics software segment aboard a Boeing 757 flying test bed;<sup>9</sup>
- demonstration that the engine allows the aircraft to fly throughout its planned flight regime (engine full flight release);
- flight up to an altitude of 50,000 feet, the maximum required (demonstrated in late 1998); and
- complete initial radar cross section testing of a full-scale model.

## Flight Test Program May Not Be Completed as Planned

Information provided by the Air Force indicates that, unless certain problems are resolved, a significant percentage of the flight test program may not be completed as planned before the development flight tests are scheduled to end. The Air Force is experiencing several problems executing the flight test program on schedule: (1) deliveries of some test aircraft have been delayed by over 8 months, (2) completed test aircraft have required more modifications than expected, and (3) the flight test program efficiency—the number of test points<sup>10</sup> accomplished for each flight test hour—has been less than planned. According to an Air Force analysis, if these problems persist, 37 to 50 percent of the total planned flight test hours would not be completed by the time F-22 development is scheduled to be completed.

The Air Force, in June 1999, reported further delays<sup>11</sup> in test aircraft deliveries because of additional delays in wing deliveries and repairs

<sup>8</sup> Changing the direction of the thrust generated by the aircraft's engines to make the aircraft more maneuverable.

<sup>9</sup> Tests involved primarily the radar, not the more sophisticated integrated avionics capability, which includes communication, navigation, and identification and electronic warfare functions.

<sup>10</sup> A test point is one of thousands of measurements of the performance of individual functions of the aircraft and its components in a range of conditions and flight environments.

<sup>11</sup> For a description of previous delays in the completion of test aircraft, see *F-22 Aircraft: Issues in Achieving Engineering and Manufacturing Development Goals* (GAO/NSIAD-99-55, Mar. 15, 1999).

needed to the aft (rear) fuselage.<sup>12</sup> Table 1 compares the first flight dates of test aircraft as planned in 1997 with the first flight dates as planned at the time of our last report in March 1999 and the Air Force plan as of June 1999.

**Table 1: Comparison of Schedules for First Flight Dates of Test Aircraft**

Test aircraft	First flight dates as planned in 1997	First flight dates as planned in March 1999	First flight dates as planned in June 1999	Total delay of first flight dates (months) as of June 1999
4001	May 1997	September 1997 <sup>a</sup>	September 1997 <sup>a</sup>	3.37
4002	July 1998	June 1998 <sup>a</sup>	June 1998 <sup>a</sup>	-0.33
4003	June 1999	November 1999	February 2000	8.17
4004	August 1999	February 2000	May 2000	8.67
4005	January 2000	March 2000	June 2000	5.67
4006	May 2000	May 2000	August 2000	2.73
4007	September 2000	September 2000	October 2000	0.73
4008	February 2001	February 2001	February 2001	0
4009	June 2001	June 2001	June 2001	0
<b>Total</b>				<b>29.01</b>

<sup>a</sup>Actual date of first flight.

Because of manufacturing problems, the third test aircraft (4003) will be delivered over 8 months later than planned in 1997, and the next four flight test aircraft will also be delivered late. However, the Air Force has not extended the date for completion of the development program. As a result, the Air Force now has over 29 fewer flight test months available to complete the development flight test program and has lost over 626 flight test hours that would have been available had these aircraft been delivered on schedule. Flight test time is essential to verify an aircraft's specific features and to reduce the risk of structural or performance problems emerging after production begins.

<sup>12</sup> In April 1999, an airframe structural strength analysis indicated insufficient strength in a panel in the rear of the airframe. Development aircraft are being repaired to provide additional structural strength.

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Furthermore, the June 1999 schedule for conducting first flights of aircraft 4005 through 4008 may also be overly optimistic. In December 1999 the Air Force reported to the Under Secretary of Defense for Acquisition, Technology, and Logistics that delivery of aircraft 4005 through 4008 was expected to be further delayed, delaying first flight dates of these aircraft by 2 to 3 months. Air Force officials told us that they would have to pay overtime labor rates to meet the original schedule and that they are willing to accept later delivery to save money.

Air Force officials also told us that one of the major reasons the flight test program may not be completed as planned is that the two deployed F-22 test aircraft have required many more modifications than anticipated since flight tests began in September 1997. As a result, these aircraft have not been available for the planned amount of flight testing.

The flight test program has not been as efficient as expected. A gauge of the efficiency of flight tests is the number of test points achieved in each flight test hour. Flight testing through December 1999 did not achieve test points at a sufficient rate to complete the flight test program as planned. At the current rate, the development program may not achieve as much as one-third or more of its planned flight test points by the time operational testing begins. The program is currently achieving 8.1 test points per flight test hour. To complete the program as planned, the Air Force would have to increase its rate to 12.5 test points per flight test hour for the remainder of the airframe performance portion of the flight test program (see table 2). To achieve 12.5 test points per flight hour, the Air Force will have to increase the accomplishment rate to a level substantially above the planned accomplishment rate of 11.3.

**Table 2: Comparison of Planned, Current, and Needed F-22 Airframe Performance Flight Test Point Accomplishment Rates**

Flight test accomplishment plans	Flight test points	Flight test hours	Flight test point accomplishment rate (per flight test hour)
Planned accomplishment	20,125	1,787	11.3
Accomplishment through December 1999	4,121	505.7	8.1
Accomplishment needed to complete airframe performance flight test program as planned	16,004	1,281.3	12.5

The Air Force maintains that it is managing the flight test program aggressively by improving test efficiency, prioritizing work, and reducing overall test point requirements without affecting weapon system capabilities. However, if the flight test program continues at about its current flight test point accomplishment rate, the Air Force will have to eliminate over 35 percent of the airframe performance flight test points—in other words, it will not be able to complete over one-third of the flight test points unless more flight tests hours are flown or flight tests are extended.

### Avionics Development Is Behind Schedule, Remaining Schedule Appears Optimistic

In 1997, a study team concluded that avionics development could take as much as 12 months longer than planned because of delays in the development of major avionics segments, known as blocks (1, 2, 3, and 3.1). Completion of each avionics segment depends on completion of prior segments. Block 1 was completed<sup>13</sup> behind schedule. Currently, block 2 is also expected to be completed behind the 1997 schedule, and the majority of initial software development tasks related to blocks 3 and 3.1 have been delayed between 1 and 14 months behind the 1997 schedule. Although it postponed the completion dates for blocks 1 and 2, the Air Force moved up the planned completion dates for blocks 3 and 3.1. According to the current avionics schedule, the Air Force is planning on blocks 3 and 3.1 being completed 5 and 3 months, respectively, earlier than the dates considered realistic by the study team. If the Air Force's current avionics schedule is not achieved, additional costs will be incurred to complete avionics development.

<sup>13</sup> Completed to the point that it is placed on an aircraft in preparation for flight testing.

There have also been significant delays in the start of avionics flight tests. Flight tests of block 1, which were supposed to begin aboard the fourth test aircraft in August 1999, have been delayed until May 2000. At the same time, flight tests of block 3 are still planned 5 months earlier than the date considered realistic in 1997.

### Testing of Nonflying Ground Test Aircraft Continues to Be Delayed

Two major tests of the structural integrity of the F-22's airframe have been delayed significantly. Static testing is designed to ensure the aircraft will withstand stresses throughout the aircraft's flight regime, and fatigue testing subjects the aircraft to the structural stresses expected within its planned life. These tests are important to reduce the risk of structural problems emerging during the production phase. The completion dates for these tests have been delayed 13 and 14 months, respectively. Table 3 shows the delayed completion dates for these tests.

**Table 3: Delays in Planned Completion of Static and Fatigue Structural Integrity Tests**

Test	1997 plan	March 1999 plan	December 1999 plan	Total delay (months)
Static	October 1999	February 2000	November 2000	13
Fatigue	December 1999	September 2000	February 2001	14

### Extent to Which the F-22 Program Is Meeting Cost Goals

The F-22 development program can be managed within the cost limitation of \$20.4 billion only if the current completion date for the program is not extended and if additional cost increases can be managed within the current projected surplus. The Air Force and contractors have identified initiatives to produce sufficient cost offsets to complete the development program within the cost limitation. The Air Force reports that these initiatives will total about \$860 million, or \$103 million more than needed to offset the total projected cost growth of \$757 million. However, there are risks that (1) contractor costs will continue to exceed budgets more than expected and (2) overhead costs for the F-22 program will increase because sales of the C-130J cargo aircraft, which is manufactured in the same plant as the F-22, have been lower than expected, thereby increasing overhead costs to the F-22 program. Furthermore, as explained previously, there is the possibility that flight tests and the development program itself

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will be extended if aircraft manufacturing and avionics problems continue or if the Air Force is unable to reduce the necessary modifications to test aircraft or increase the efficiency of the flight test program. Any of these conditions could increase program costs.

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## Status of Initiatives

In late 1998, the Air Force identified \$667 million in potential cost increases that could cause the development program to exceed its cost limitation. To keep development program costs from exceeding the congressional cost limitation, the Air Force and contractors developed a number of cost reduction initiatives aimed at offsetting the projected \$667 million cost increase. The Air Force reported in December 1999 that these initiatives were expected to result in \$730 million in offsets to the F-22 development program cost. These initiatives include the following:

- Contractor management efficiencies (\$360 million). Lockheed Martin has developed a number of initiatives to improve the efficiency of assembling the F-22 while reducing costs. One of these involves closing some contractor laboratories earlier than planned. Another is a management approach that emphasizes reduction of unneeded steps in the manufacturing process. Air Force officials stated that initiatives implemented through November 1999 would achieve an estimated \$328 million of cost savings, but initiatives expected to result in \$32 million of savings have not yet been implemented.
- Applying management reserve (\$180 million). This is essentially an accounting adjustment. Management reserve is the balance of funds available within the contract price that the contractor has not budgeted for planned work. The purpose of management reserve is to provide flexibility in managing increases and decreases in budgets and the actual costs of completing the planned work. Because the contractor's costs exceeded budgeted amounts, the management reserve balance (totaling \$180 million) will be used to offset the increased costs. One effect of this action will be that the contractor will not have flexibility in managing future cost increases.
- Deferring weapon testing (\$140 million). The Air Force deferred indefinitely tests of some weapons to be carried externally on the aircraft because the F-22's primary mission is to carry weapons internally. Carrying weapons externally would substantially decrease the F-22's stealth capabilities. The deferral reduces F-22 development costs but may require the costs, when incurred, to be charged to an account different from the one used for F-22 development.

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- Eliminating all remaining government studies for which funds have already been allocated (\$50 million) and applying the funds to cost increases in other F-22 development program activities.

The Air Force also plans to exempt the F-22 development program from contributing to a servicewide research fund, thus freeing up an additional \$130 million. In testimony before the House Committee on Government Reform, Subcommittee on National Security, Veterans Affairs, and International Relations, the Air Force announced in December 1999 that it would not take funds from the F-22 development program to pay for small business innovative research programs intended to benefit the Air Force as a whole. The funds are usually taken from most Air Force programs. This initiative, however, may require other Air Force programs to make up for the loss of research funds that would have been obtained from the F-22 program.

With \$730 million in offsets and an additional \$130 million available from not contributing to the servicewide research fund, the Air Force has a total of \$860 million to offset the \$757 million in projected cost increases. This provides a surplus of as much as \$103 million to absorb additional cost increases if necessary.

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### Contractor Costs Continuing to Grow More Than Projections

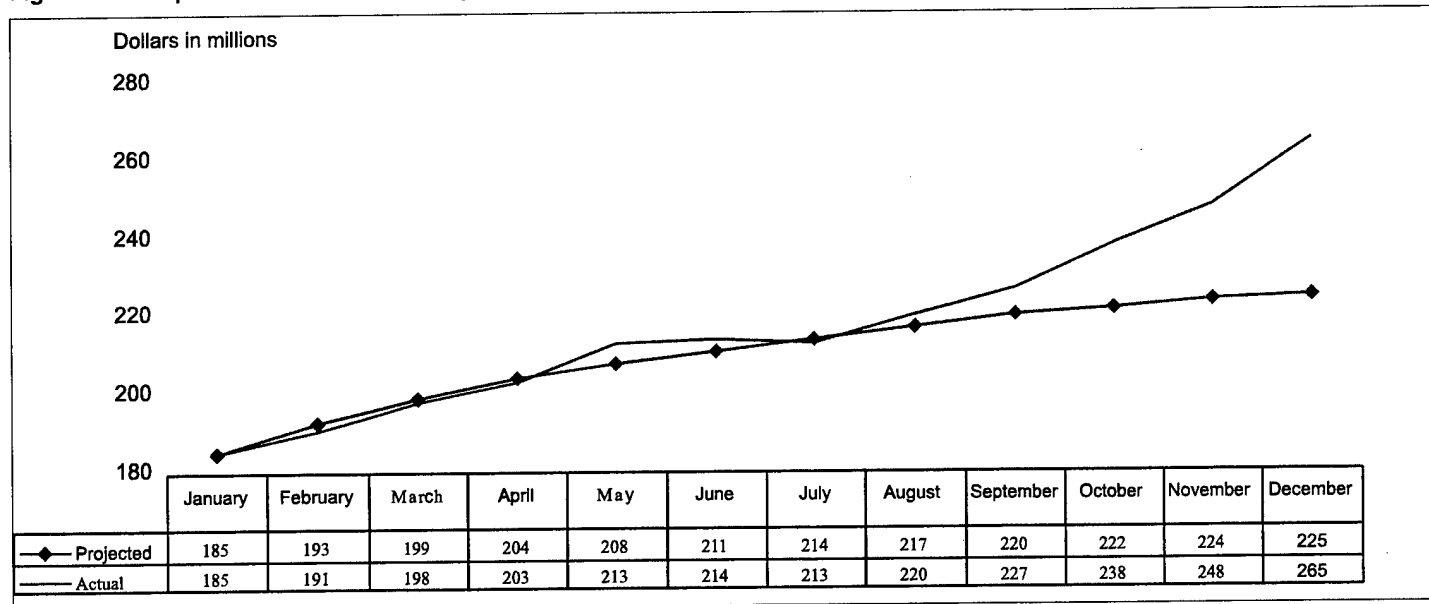
Contractor costs continued to increase in 1999 and again exceeded available budgets by more than projected. Through 1998, contractor costs had exceeded available budgets by a total of \$185 million since the Joint Estimating Team program restructure in 1997. Lockheed Martin had expected its costs for 1999 to exceed the available budget by another \$40 million for a total of \$225 million since the Joint Estimating Team program restructure in 1997. But by September 1999, costs for the year exceeded the \$40 million expected growth, despite the contractor's establishment of plans to limit the cost growth. Through December 1999, costs had exceeded available budgets by \$80 million in 1999, for a total of \$265 million since the Joint Estimating Team program restructure in 1997. This brings into question the contractor's ability to control costs enough to complete the development program as planned within the cost limitation.

The Air Force attributes these cost increases to production labor costs, manufacturing support and assembly labor cost overruns, and certain types of work performed out of sequence. Delayed software deliveries and avionics redesign, rework, and supplier overruns also contributed to cost increases. The Air Force acknowledges that because of the contractor cost

increases in 1999, overall development program costs are likely to grow by an additional \$90 million above the projected cost growth of \$667 million.

Figure 1 compares actual cost growth with Lockheed Martin's projections from January through December 1999.

**Figure 1: Comparison of Actual and Projected Cost Growth Above Budget, January Through December 1999**



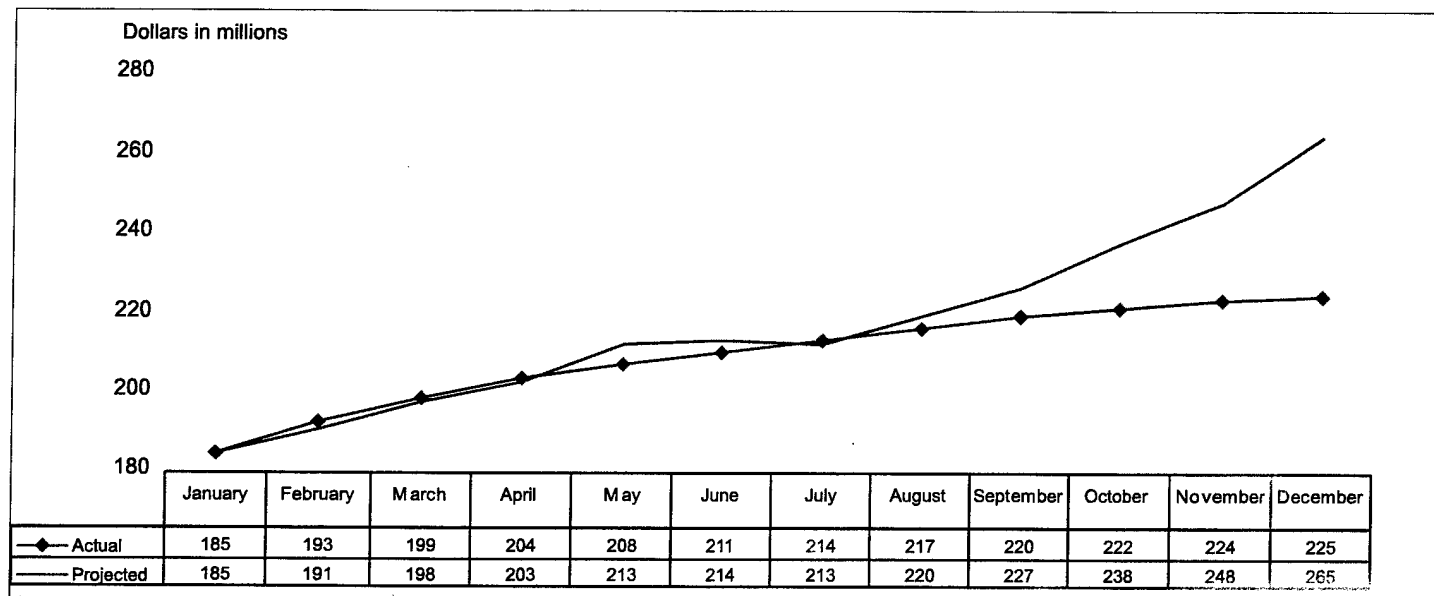
Among the factors contributing to higher contractor costs and manufacturing problems is the fact that the next four flight test aircraft are projected to take more hours than planned to assemble (see table 4). Also, except in April, the number of contractor personnel assigned to the program was consistently higher than planned for 1999 (see fig. 2). Labor costs make up a large portion of total program costs; therefore, taking longer than planned to assemble the aircraft and maintaining consistently higher personnel levels than planned increases program costs above estimates.



**Table 4: Comparison of Air Force Planned and Projected Assembly Hours for Flight Test Aircraft 4003-4009, December 1999**

Test aircraft	Planned assembly hours, December 1999	Projected assembly hours, December 1999	Difference	Percent difference
4003	269,360	274,158	4,798	1.8
4004	232,546	260,471	27,925	12.0
4005	207,342	228,260	20,918	10.1
4006	205,822	220,991	15,169	7.4
4007	201,815	201,815	0	0
4008	197,168	197,168	0	0
4009	175,919	175,919	0	0

**Figure 2: Actual and Planned Contractor Personnel Levels in 1999**



## Potential Impact of C-130J Sales on Program

Unexpectedly low sales of the C-130J cargo aircraft produced by Lockheed Martin may affect F-22 program costs. The C-130J, the F-22, and several other weapon systems are produced or modified at the same Lockheed Martin plant in Marietta, Georgia. Lower C-130J production would mean

that a larger share of plant overhead costs might have to be absorbed partly by the F-22. The assumption had been that 24 or 25 C-130J aircraft would be produced each year. However, it now appears the C-130J program will not achieve these production rates. Only 19 aircraft were produced in fiscal year 1999, and only 17 are estimated to be produced in fiscal year 2000 and 16 in each of the following 3 fiscal years. The Defense Contract Management Command analyzed this new information and concluded that this reduction in aircraft production could result in approximately \$45 million in unabsorbed overhead costs per year at the plant. This amount would need to be absorbed by all government programs at the plant, including possibly the F-22 program. The specific impact of all this on the F-22 program has not yet been determined.

## Agency Comments and Our Evaluation

DOD concurred with a draft of our report. DOD's comments are reproduced in appendix III. DOD suggested additional technical changes, which we incorporated in the report where appropriate.

## Scope and Methodology

To determine whether the development program is likely to meet performance goals, we analyzed information on the performance of key performance parameters and those sub-parameters that are measured. We compared performance goals established by the Under Secretary of Defense for Acquisition, Technology, and Logistics with the Air Force's current estimates of performance in December 1999 and at completion of development. The performance parameters are shown in appendix I.

To determine whether the program is expected to meet schedule goals, we reviewed program and avionics schedules and discussed potential changes to these schedules with F-22 program officials. We also compared current schedules with those developed in 1997 as a result of a study by the Joint Estimating Team. We tracked progress in the flight test program, evaluated schedule variances in the contractors' performance management system, and compared planned milestone accomplishment dates with actual dates. We tracked technical problems in manufacturing and assembling the development aircraft.

To determine whether the program is likely to meet the cost limitation, we examined (1) the extent to which the development program cost goals are being met, (2) Air Force plans to fund the program for fiscal year 2001, and (3) consistencies between the program funding plan and the cost

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limitation. We compared the estimated cost at completion of the prime contracts with planned amounts, evaluated cost variances identified in the contractors' cost reporting systems, and reviewed the status of initiatives designed to avoid cost growth.

To assess the extent to which the F-22 development program was meeting its performance, schedule, and cost goals, we required access to current information about test results, performance estimates, schedule achievements and revisions, and incurred costs. The Air Force and contractors gave us access to sufficient information to make informed judgments on the matters covered in this report.

In performing our work, we obtained information and interviewed officials from the Office of the Secretary of Defense, Washington D.C.; the F-22 System Program Office, Wright-Patterson Air Force Base, Ohio; the Defense Contract Management Command, Marietta, Georgia; Lockheed Martin Aeronautical Systems, Marietta, Georgia; Lockheed Martin Tactical Aircraft Systems, Fort Worth, Texas; and Boeing Military Aircraft, Seattle, Washington.

We performed our work from April 1999 through February 2000 in accordance with generally accepted government auditing standards.

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We are sending copies of this report to the Honorable Senator John W. Warner, Chairman, Committee on Armed Services; the Honorable Senator Ted Stevens, Chairman, Subcommittee on Defense, Committee on Appropriations; the Honorable Representative Floyd D. Spence, Chairman, Committee on Armed Services; the Honorable Representative Jerry Lewis, Chairman, Subcommittee on Defense, Committee on Appropriations; the Honorable William Cohen, Secretary of Defense; the Honorable F. Whitten Peters, Secretary of the Air Force; and the Honorable Jacob Lew, Director, Office of Management and Budget. Copies will also be made available to others on request.

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Please contact Allen Li at (202) 512-4841 or Robert D. Murphy at (937) 258-7904 if you or your staff have any questions concerning this report. Major contributors to this report are listed in appendix IV.

A handwritten signature in cursive script, reading "Louis J. Rodrigues". The signature is written in black ink and is positioned above the printed name and title.

Louis J. Rodrigues  
Director, Defense Acquisitions Issues

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List of Congressional Committees

The Honorable John W. Warner  
Chairman

The Honorable Carl Levin  
Ranking Minority Member  
Committee on Armed Services  
United States Senate

The Honorable Ted Stevens  
Chairman

The Honorable Daniel K. Inouye  
Ranking Minority Member  
Subcommittee on Defense  
Committee on Appropriations  
United States Senate

The Honorable Floyd D. Spence  
Chairman

The Honorable Ike Skelton  
Ranking Minority Member  
Committee on Armed Services  
House of Representatives

The Honorable Jerry Lewis  
Chairman

The Honorable John P. Murtha  
Ranking Minority Member  
Subcommittee on Defense  
Committee on Appropriations  
House of Representatives



# Estimates of Performance for Key F-22 Parameters

**Table 5: Estimates of Performance for Key Parameters**

Key performance parameters	Goal (acquisition program baseline)	Estimated December 1999 performance	Estimated performance at completion of development
Supercruise	100 percent	115 percent	115 percent
Acceleration	100 percent	114 percent	114 percent
Maneuverability	100 percent	104 percent	104 percent
Airlift support (C-141 equivalents)	8	7.4	7.4
Sortie generation rate	100 percent	100 percent	100 percent
Radar cross section (front sector only)	100 percent	Estimated to meet requirements (data classified)	Estimated to meet requirements (data classified)
Mean time between maintenance (hours)	3.0	3.0	3.0
Payload (missiles)	four medium-range, two short-range	six medium-range, two short-range	six medium-range, two short-range
Combat radius	100 percent	123 percent	123 percent
Radar detection range	100 percent	117 percent	117 percent

# Criteria Established by the Under Secretary of Defense for Acquisition, Technology, and Logistics for the F-22 Program

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Criteria to be completed before approval to award contracts to acquire six aircraft for fiscal year 2000 (awarded in Dec. 1999):

- Demonstrate flight up to 50,000 feet.
- Engine full flight release.
- Conduct weapon bay open testing (initiate data analysis).
- Complete avionics integration laboratory integration of the operational flight program block 1.1 software and deliver to manufacturer.
- Complete critical design review for avionics block 3 software.
- Complete aircraft 4004 fuselage, wing, and empennage mate.
- Demonstrate supercruise.
- Release avionics block 2 software to the flying test bed.
- Complete static test up to 100 percent of the design limit load on critical structure.
- Conduct flight test operations in zones E-2, E-2A, E-3, E-3A, and E-4.
- Complete initial radar cross section full-scale pole model testing.
- Demonstrate high angle of attack post-stall flight with thrust vectoring.
- Complete aircraft 4003 flight preparation up through installed engine runs.

Criteria that are prerequisites for approval to award contracts to begin low-rate initial production (planned for Dec. 2000):

- Complete first portion of engine initial service release qualification test (2,150 total accumulated cycles, ½ full hot section life).
- Complete air vehicle final production readiness review.
- Complete first flight on flight test aircraft 4003, 4004, 4005, and 4006.
- Complete flight test aircraft 4008 fuselage, wing, and empennage mate.
- Complete static structural testing.
- Complete critical design review for avionics block 3.1 software.
- Complete avionics block 3.0 first flight, initiate testing of block 3.0 unique functionality.
- Conduct flight testing on flight test aircraft, including initiating radar cross section flight testing, initiating high angle of attack testing with weapons bay doors open, and initiating separation testing of Air Intercept Missile-9 and the Air Intercept Missile-120.
- Initiate fatigue life testing with the goal of completing 40 percent of first fatigue life.



# Comments From the Department of Defense



ACQUISITION AND  
TECHNOLOGY

OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON  
WASHINGTON DC 20301-3000

Mr. Louis J. Rodrigues  
Director, Defense Acquisitions Issues  
National Security and International  
Affairs Division  
U.S. General Accounting Office  
Washington, D.C. 20548

Dear Mr. Rodrigues:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, "F-22 AIRCRAFT: Development Cost Goal Achievable If Major Problems are Avoided," dated January 27, 2000 (GAO Code 707413/ OSD Case 1940).

The DoD has reviewed the draft report and concurs without further comment. Suggested technical changes for clarification and accuracy have been provided separately.

The Department appreciates the opportunity to comment on the draft report.

Sincerely,

George R. Schneider  
Director  
Strategic and Tactical Systems



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# GAO Staff Acknowledgments

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## Acknowledgments

Mark Abraham, Marvin E. Bonner, Christopher T. Brannon, Edward R. Browning, Shirley Johnson, Don M. Springman, and John Van Schaik made key contributions to this report.

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# Related GAO Products

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*Defense Acquisitions: Progress in Meeting F-22 Cost and Schedule Goals* (GAO/T-NSIAD-00-58, Dec. 7, 1999).

*Fiscal Year 2000 Budget: DOD's Procurement and RDT&E Programs* (GAO/NSIAD-99-233R, Sep. 23, 1999).

*Budget Issues: Budgetary Implications of Selected GAO Work for Fiscal Year 2000* (GAO/OCG-99-26, Apr. 16, 1999).

*Defense Acquisitions: Progress of the F-22 and F/A-18E/F Engineering and Manufacturing Development Programs* (GAO/T-NSIAD-99-113, Mar. 17, 1999).

*F-22 Aircraft: Issues in Achieving Engineering and Manufacturing Development Goals* (GAO/NSIAD-99-55, Mar. 15, 1999).

*F-22 Aircraft: Progress of the Engineering and Manufacturing Development Program* (GAO/T-NSIAD-98-137, Mar. 25, 1998).

*F-22 Aircraft: Progress in Achieving Engineering and Manufacturing Development Goals* (GAO/NSIAD-98-67, Mar. 10, 1998).

*Tactical Aircraft: Restructuring of the Air Force F-22 Fighter Program* (GAO/NSIAD-97-156, June 4, 1997).

*Defense Aircraft Investments: Major Program Commitments Based on Optimistic Budget Projections* (GAO/T-NSIAD-97-103, Mar. 5, 1997).

*F-22 Restructuring* (GAO/NSIAD-97-100BR, Feb. 28, 1997).

*Tactical Aircraft: Concurrency in Development and Production of F-22 Aircraft Should Be Reduced* (GAO/NSIAD-95-59, Apr. 19, 1995).

*Air Force Embedded Computers* (GAO/AIMD-94-177R, Sep. 20, 1994).

*Tactical Aircraft: F-15 Replacement Issues* (GAO/T-NSIAD-94-176, May 5, 1994).

*Tactical Aircraft: F-15 Replacement Is Premature as Currently Planned* (GAO/NSIAD-94-118, Mar. 25, 1994).

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